

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau(43) International Publication Date
7 February 2002 (07.02.2002)

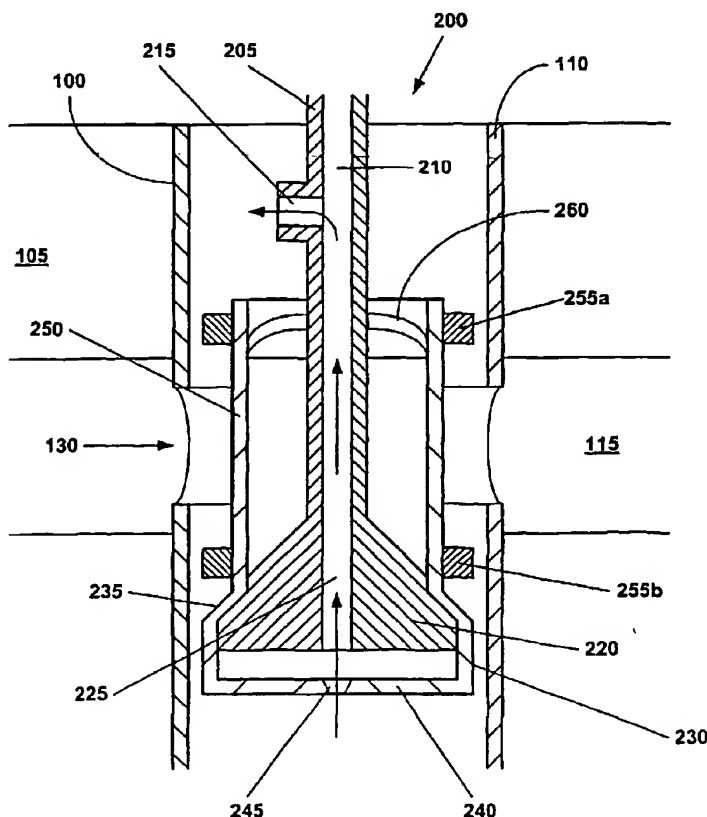
PCT

(10) International Publication Number
WO 02/10551 A1

- (51) International Patent Classification⁷: **E21B 29/10, 43/10** **RING, Lev** [RU/US]; 14126 Heatherhill Place, Houston, TX 77077 (US).
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- (22) International Filing Date: 27 July 2001 (27.07.2001)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data: 60/221,443 28 July 2000 (28.07.2000) US
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- (81) Designated States (national): AR, AG, AI, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.
- (84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF,

[Continued on next page]

(54) Title: LINER HANGER WITH SLIP JOINT SEALING MEMBERS AND METHOD OF USE



(57) Abstract: An apparatus (200) and method for repairing an opening (130) in a wellbore casing (110). The apparatus (200) and method couple a floating tubular (250) member in opposing relation to the opening (130) in the wellbore casing (110).

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WO 02/10551 A1



CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD,
TG).

with amended claims

Published:

— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

LINER HANGER WITH SLIP JOINT
SEALING MEMBERS

Cross Reference To Related Applications

This application claims the benefit of the filing date of U.S. provisional patent application serial number 60/221,443, attorney docket number 25791.45, filed on 7/28/2000, the disclosure of which is
5 incorporated herein by reference.

This application is related to the following co-pending applications:
(1) U.S. patent application serial no. 09/440,338, attorney docket number 25791.9.02, filed on 11/15/1999, which claimed benefit of the filing date of U.S. provisional patent application serial number 60/108,558, attorney
10 docket number 25791.9, filed on 11/16/1998, (2) U.S. patent application serial no. 09/454,139, attorney docket number 25791.3.02, filed on 12/3/1999, which claimed benefit of the filing date of U.S. provisional patent application serial number 60/111,293, filed on 12/7/1998, (3) U.S. patent application serial number 09/502,350, attorney docket number
15 25791.8.02, filed on 2/10/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/119,611, attorney docket number 25791.8, filed on 2/11/1999, (4) U.S. patent application serial number 09/510,913, attorney docket number 25791.7.02, filed on 2/23/2000, which claimed the benefit of the filing date of U.S. provisional
20 patent application serial number 60/121,702, attorney docket number 25791.7, filed on 2/25/1999, (5) U.S. patent application serial number 09/511,941, attorney docket number 25791.16.02, filed on 2/24/2000, which claimed the benefit of the filing date of U.S. provisional patent application number 60/121,907, attorney docket number 25791.16, filed on
25 2/26/1999, (6) U.S. patent application serial number 09/523,460, attorney docket number 25791.11.02, filed on 3/10/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/124,042, attorney docket number 25791.11, filed on 3/11/1999, (7) U.S. patent application serial number 09/559,122, attorney docket number

25791.23.02, filed on 4/26/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/131,106, attorney docket number 25791.23, filed on 4/26/1999, (8) U.S. patent application serial number _____, attorney docket number

5 25791.17.02, filed on _____, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/137,998, attorney docket number 25791.17, filed on 6/7/1999, (9) U.S. provisional patent application serial number 60/143,039, attorney docket number

10 25791.26, filed on 7/9/1999, (10) U.S. provisional patent application serial number 60/146,203, attorney docket number 25791.25, filed on 7/29/1999, the disclosures of which are incorporated by reference; (11) U.S. provisional patent application serial number 60/183,546, attorney docket number 25791.10, filed on 2/18/2000; (12) U.S. patent application serial number 09/512,895, attorney docket number 25791.12.02, filed on

15 2/24/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/121,841, attorney docket number 25791.12, filed on 2/26/1999; (13) U.S. provisional patent application serial number _____, attorney docket number 25791.38, filed on 6/19/2000; (14) U.S. provisional patent application serial number

20 60/162,671, attorney docket number 25791.27, filed on 11/1/1999; (15) U.S. provisional patent application serial number 60/159,039, attorney docket number 25791.36, filed on 10/12/1999; (16) U.S. provisional patent application serial number 60/159,033, attorney docket number 25791.37, filed on 10/12/1999; (17) U.S. provisional patent application serial number

25 60/165,228, attorney docket number 25791.39, filed on 11/12/1999; and (18) U.S. provisional patent application serial number _____, attorney docket number 25791.46, filed on _____, the disclosures of which are incorporated herein by reference.

Background of the Invention

30 This invention relates generally to wellbore casings, and in particular to apparatus and methods for repairing wellbore casings.

Conventionally, when a wellbore casing is damaged, a tubular liner is positioned within the damaged section of the wellbore casing in order to provide structural support and prevent the undesired outflow of drilling fluid into the formation or inflow of fluid from the formation into the borehole. However, conventional tubular liners used for repairing damaged sections of wellbore casings suffer from a number of serious drawback. For example, conventional tubular liners used for repairing damaged sections of wellbore casings are not designed to accommodate variable loading conditions.

The present invention is directed to overcoming one or more of the limitations of the existing apparatus and methods for repairing damaged sections of wellbore casings.

Summary of the Invention

According to one aspect of the present invention, a method of repairing a damaged section of a wellbore casing is provided that includes removing at least a portion of the damaged section of the wellbore casing to create an opening in the wellbore casing, and covering at least a portion of the opening in the wellbore casing with a floating tubular member.

According to another aspect of the present invention, a radially expandable tubular member for repairing an opening in a wellbore casing is provided that includes a tubular member and a slip joint coupled to the exterior surface of the tubular member.

According to another aspect of the present invention, an apparatus for repairing an opening in a wellbore casing is provided that includes a tubular support member including a first passage, an expansion cone coupled to the tubular support member including a second passage fluidically coupled to the first passage, an expansion cone launcher coupled to the expansion cone including a shoe having an exhaust passage, and an expandable tubular member coupled to the expansion cone launcher including one or more sealing members having slip joints.

According to another aspect of the present invention, an apparatus is provided that includes a wellbore casing including an opening, and a floating tubular member coupled to the wellbore casing in opposing relation to the opening.

5 According to another aspect of the present invention, a system for repairing a damaged section of a wellbore casing is provided that includes means for removing at least a portion of the damaged section of the wellbore casing to create an opening in the wellbore casing, and means for covering at least a portion of the opening in the wellbore casing with a
10 floating tubular member.

Brief Description of the Drawings

FIG. 1 is a cross-sectional view illustrating a wellbore casing including a damaged section.

15 FIG. 2 is a fragmentary cross-sectional view illustrating the introduction of a milling device into the wellbore casing of FIG. 1.

FIG. 3 is a fragmentary cross-sectional view illustrating the removal of at least a portion of the damaged section of the wellbore casing using the milling device to form an opening in the wellbore casing of FIG. 2.

20 FIG. 4 is a fragmentary cross-sectional view illustrating the placement of a repair apparatus for covering the opening in the wellbore casing of FIG. 3.

FIG. 5 is a fragmentary cross-sectional view illustrating the injection of fluidic materials into the repair apparatus of FIG. 4.

25 FIG. 6 is a fragmentary cross-sectional view illustrating the pressurization of the interior of the repair apparatus of FIG. 5.

FIG. 7 is a fragmentary cross-sectional view illustrating the completion of the radial expansion of the expandable tubular member of the repair apparatus of FIG. 6.

30 FIG. 8 is a cross-sectional view illustrating the milling out of the shoe of the radially expanded tubular member of FIG. 7.

FIG. 9 is a cross-sectional illustration of an embodiment of upper and lower sealing members that include internal slip joints.

Detailed Description of the Illustrative Embodiments

An apparatus and method for repairing an opening in a damaged section of a wellbore casing within a subterranean formation is provided. The apparatus and method provides a system for repairing an opening in a damaged section of a wellbore casing within a subterranean formation in which a tubular member is radially expanded into contact with the wellbore casing. The physical connection between the radially expanded tubular member and the wellbore casing is preferably compliant and permits movement of the radially expanded tubular member relative to the wellbore casing in at least the longitudinal direction. In this manner, the radially expanded tubular member is capable of absorbing a wide range of loading conditions.

Referring initially to Fig. 1, a wellbore 100 positioned within a subterranean formation 105 includes a preexisting casing 110 that traverses a producing formation 115. The portion of the casing 110 that traverses the producing formation 115 includes a damaged section 120. As will be recognized by persons having ordinary skill in the art, the damaged section 120 may be caused by, for example, structural instabilities in the producing formation 115 such as, for example, subsidence that can cause buckling of the wellbore casing 110.

Referring to Figs. 2 and 3, in order to repair the damaged section 120 of the wellbore casing 110, a conventional milling device 125 is then inserted into the wellbore casing 110. The milling device 125 is then used to remove at least a portion of the damaged section 120 of the wellbore casing 110 and thereby form an opening 130 in the wellbore casing 110.

Referring to Fig. 4, an apparatus 200 for repairing the opening 130 in the wellbore casing 110 may then be positioned within the wellbore casing proximate the opening in the wellbore casing.

The apparatus 200 includes a tubular support member 205 having a longitudinal passage 210 and a transverse passage 215 that is coupled to an expansion cone 220 having a longitudinal passage 225 that is fluidically coupled to the longitudinal passage 210. The expansion cone 220 is at least partially received within an expansion cone launcher 230 that includes a thin-walled annular member 235 and a shoe 240 having an exhaust passage 245. An expandable tubular member 250 extends from the expansion cone launcher 230 that includes upper and lower sealing members 255a and 255b affixed to the exterior surface of the expandable tubular member. A sealing cup 260 is attached to the exterior surface of the tubular support member 205 for preventing foreign materials from entering the interior of the expandable tubular member 250.

In a preferred embodiment, the apparatus 200 is provided as disclosed in one or more of the following: (1) U.S. patent application serial no. 09/440,338, attorney docket number 25791.9.02, filed on 11/15/1999, which claimed benefit of the filing date of U.S. provisional patent application serial number 60/108,558, attorney docket number 25791.9, filed on 11/16/1998, (2) U.S. patent application serial no. 09/454,139, attorney docket number 25791.3.02, filed on 12/3/1999, which claimed benefit of the filing date of U.S. provisional patent application serial number 60/111,293, filed on 12/7/1998, (3) U.S. patent application serial number 09/502,350, attorney docket number 25791.8.02, filed on 2/10/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/119,611, attorney docket number 25791.8, filed on 2/11/1999, (4) U.S. patent application serial number 09/510,913, attorney docket number 25791.7.02, filed on 2/23/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/121,702, attorney docket number 25791.7, filed on 2/25/1999, (5) U.S. patent application serial number 09/511,941, attorney docket number 25791.16.02, filed on 2/24/2000, which claimed the benefit of the filing date of U.S. provisional patent application number

60/121,907, attorney docket number 25791.16, filed on 2/26/1999, (6) U.S. patent application serial number 09/523,460, attorney docket number 25791.11.02, filed on 3/10/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/124,042, attorney docket number 25791.11, filed on 3/11/1999, (7) U.S. patent application serial number 09/559,122, attorney docket number 25791.23.02, filed on 4/26/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/131,106, attorney docket number 25791.23, filed on 4/26/1999, (8) U.S. patent application serial number _____, attorney docket number 25791.17.02, filed on _____, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/137,998, attorney docket number 25791.17, filed on 6/7/1999, (9) U.S. provisional patent application serial number 60/143,039, attorney docket number 25791.26, filed on 7/9/1999, (10) U.S. provisional patent application serial number 60/146,203, attorney docket number 25791.25, filed on 7/29/1999, the disclosures of which are incorporated by reference; (11) U.S. provisional patent application serial number 60/183,546, attorney docket number 25791.10, filed on 2/18/2000; (12) U.S. patent application serial number 09/512,895, attorney docket number 25791.12.02, filed on 2/24/2000, which claimed the benefit of the filing date of U.S. provisional patent application serial number 60/121,841, attorney docket number 25791.12, filed on 2/26/1999; (13) U.S. provisional patent application serial number _____, attorney docket number 25791.38, filed on 6/19/2000; (14) U.S. provisional patent application serial number 60/162,671, attorney docket number 25791.27, filed on 11/1/1999; (15) U.S. provisional patent application serial number 60/159,039, attorney docket number 25791.36, filed on 10/12/1999; (16) U.S. provisional patent application serial number 60/159,033, attorney docket number 25791.37, filed on 10/12/1999; and (17) U.S. provisional patent application serial

number 60/165,228, attorney docket number 25791.39, filed on 11/12/1999, the disclosures of which are incorporated herein by reference.

As illustrated in Fig. 4, during placement of the apparatus 200 within the wellbore casing 110, fluidic materials displaced by the apparatus 200 are conveyed through the longitudinal passages 210 and 225 to the transverse passage 215. In this manner, surge pressures during the placement of the apparatus 200 within the wellbore casing 110 are minimized. Furthermore, as illustrated in Fig. 4, the apparatus 200 is preferably positioned with the tubular member 250 in opposing relation to the opening 130 in the wellbore casing 110. In this manner, the upper and lower sealing members 255a and 255b may engage portions of the wellbore casing 110 above and below the opening 130 after radially expanding the tubular member 250.

As illustrated in Fig. 5, the transverse passage 215 may then be closed and fluidic materials injected into the apparatus 200 through the longitudinal passage 210. In this manner, any blockages within any of the passages 210, 225, and 245 may be detected by monitoring the operating pressure whereby an increase in operating pressure above nominal, or predetermined, conditions may indicate a blockage of one of the passages.

As illustrated in Fig. 6, a plug 265 or other conventional stop member may then be introduced into the fluidic materials injected into the apparatus 200 through the passage 210, and the plug 265 may be positioned within the passage 245. In this manner, the passage 245 may be sealed off. Thus, continued injection of fluidic materials into the apparatus 200 through the passage 210 may thereby pressurize a region 270 below the expansion cone 220.

As illustrated in Fig. 7, continued pressurization of the region 270 causes the expansion cone 220 to radially expand the expandable tubular member 250 off of the expansion cone. In this manner, the upper and lower sealing members 255a and 255b preferably engage the interior walls of the wellbore casing 110 above and below the opening 130 thereby

sealing off the opening. In a preferred embodiment, during the radial expansion process, the tubular support member 205 is raised out of the wellbore 100.

As illustrated in Fig. 8, the shoe 240 may then be removed using a conventional milling device. In this manner, exploration and production of subterranean regions beyond the opening 130 in the wellbore casing 110 may be conducted.

In several alternative embodiments, the upper sealing member 255a or the lower sealing member 255b are omitted from the tubular member 250. In this manner, the radially expanded tubular member 250 is permitted to float relative to the wellbore casing 110. Furthermore, in this manner, relative longitudinal and/or transverse movements of the sections of the wellbore casing 110 above and below the opening 130 may be optimally accommodated by the radially expanded tubular member 250. Finally, in this manner, damage to the radially expanded tubular member 250 that can be caused by longitudinal stresses, such as buckling, may be minimized or eliminated.

In another alternative embodiment, as illustrated in Fig. 9, the upper sealing member 255a and/or the lower sealing member 255b include internal slip joints 300a and 300b in order to permit the radially expanded tubular member 250 to float relative to the wellbore casing 110. In this manner, relative longitudinal and/or transverse movements of the sections of the wellbore casing 110 above and below the opening 130 may be optimally accommodated. Furthermore, in this manner, damage to the radially expanded tubular member 250 that can be caused by longitudinal stresses, such as buckling, may be minimized or eliminated.

In a preferred embodiment, the sealing members 255a and 255b permit the radially expanded tubular member 250 to move in the longitudinal direction while also maintaining a fluidic seal. In several alternative embodiments, the sealing members 255a and 255b are

fabricated from a resilient material such as, for example, synthetic or natural rubber.

It is understood that variations may be made in the foregoing without departing from the scope of the invention. For example, the
5 apparatus 200 may be used to repair, for example, a wellbore casing, a pipeline, or a structural support.

Although illustrative embodiments of the invention have been shown and described, a wide range of modification, changes and substitution is contemplated in the foregoing disclosure. In some
10 instances, some features of the present invention may be employed without a corresponding use of the other features. Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the scope of the invention.

Claims

What is claimed is:

- 1 1. A method of repairing a damaged section of a wellbore casing,
2 comprising:
3 removing at least a portion of the damaged section of the wellbore
4 casing to create an opening in the wellbore casing; and
5 covering at least a portion of the opening in the wellbore casing
6 with a floating tubular member.
- 1 2. The method of claim 1, further comprising:
2 coupling the tubular member to the wellbore casing with a slip
3 joint.
- 1 3. The method of claim 1, wherein covering at least a portion of the
2 opening in the wellbore casing with a floating tubular member comprises:
3 radially expanding at least a portion of the tubular member into
4 contact with the wellbore casing.
- 1 4. The method of claim 3, wherein the radially expanded tubular
2 member contacts the wellbore casing above and below the opening.
- 1 5. The method of claim 3, wherein the radially expanded tubular
2 member only contacts the wellbore casing above the opening.
- 1 6. The method of claim 3, wherein the radially expanded tubular
2 member only contacts the wellbore casing below the opening.
- 1 7. A radially expandable tubular member for repairing an opening in
2 a wellbore casing, comprising:

- 3 a tubular member; and
4 a slip joint coupled to the exterior surface of the tubular member.
- 1 8. An apparatus for repairing an opening in a wellbore casing,
2 comprising:
3 a tubular support member comprising a first passage;
4 an expansion cone coupled to the tubular support member
5 comprising a second passage fluidically coupled to the first
6 passage;
7 an expansion cone launcher coupled to the expansion cone
8 comprising a shoe having an exhaust passage; and
9 an expandable tubular member coupled to the expansion cone
10 launcher comprising one or more sealing members having
11 slip joints.
- 1 9. An apparatus, comprising:
2 a wellbore casing comprising an opening; and
3 a floating tubular member coupled to the wellbore casing in
4 opposing relation to the opening.
- 1 10. A system for repairing a damaged section of a wellbore casing,
2 comprising:
3 means for removing at least a portion of the damaged section of the
4 wellbore casing to create an opening in the wellbore casing;
5 and
6 means for covering at least a portion of the opening in the wellbore
7 casing with a floating tubular member.
- 1 11. The system of claim 10, further comprising:
2 means for coupling the tubular member to the wellbore casing with
3 a slip joint.

AMENDED CLAIMS

[received by the International Bureau on 28 December 2001 (21.12.01);
new claims 16-45 added; remaining claims unchanged (5 pages)]

- 1 12. The system of claim 10, wherein the means for covering at least a
2 portion of the opening in the wellbore casing with a floating tubular
3 member comprises:
4 means for radially expanding at least a portion of the tubular
5 member into contact with the wellbore casing.
- 1 13. The system of claim 12, wherein the means for radially expanded
2 tubular member comprises:
3 means for radially expanding the tubular member into contact with
4 the wellbore casing above and below the opening.
- 1 14. The system of claim 12, wherein the radially expanded tubular
2 member only contacts the wellbore casing above the opening.
- 1 15. The system of claim 12, wherein the radially expanded tubular
2 member only contacts the wellbore casing below the opening.
- 1 16. A method of repairing a damaged section of a pipeline, comprising:
2 removing at least a portion of the damaged section of the pipeline to
3 create an opening in the pipeline; and
4 covering at least a portion of the opening in the pipeline with a
5 floating tubular member.
- 1 17. The method of claim 16, further comprising:
2 coupling the tubular member to the pipeline with a slip joint.
- 1 18. The method of claim 16, wherein covering at least a portion of the
2 opening in the pipeline with a floating tubular member comprises:
3 radially expanding at least a portion of the tubular member into
4 contact with the pipeline.
- 1 19. The method of claim 18, wherein the radially expanded tubular
2 member contacts the pipeline above and below the opening.

- 1 20. The method of claim 18, wherein the radially expanded tubular
2 member only contacts the pipeline above the opening.
- 1 21. The method of claim 18, wherein the radially expanded tubular
2 member only contacts the pipeline below the opening.
- 1 22. A radially expandable tubular member for repairing an opening in a
2 pipeline, comprising:
3 a tubular member; and
4 a slip joint coupled to the exterior surface of the tubular member.
- 1 23. An apparatus for repairing an opening in a pipeline, comprising:
2 a tubular support member comprising a first passage;
3 an expansion cone coupled to the tubular support member
4 comprising a second passage fluidically coupled to the first
5 passage;
6 an expansion cone launcher coupled to the expansion cone
7 comprising a shoe having an exhaust passage; and
8 an expandable tubular member coupled to the expansion cone
9 launcher comprising one or more sealing members having slip
10 joints.
- 1 24. An apparatus, comprising:
2 a pipeline comprising an opening; and
3 a floating tubular member coupled to the pipeline in opposing
4 relation to the opening.
- 1 25. A system for repairing a damaged section of a pipeline, comprising:
2 means for removing at least a portion of the damaged section of the
3 pipeline to create an opening in the pipeline; and
4 means for covering at least a portion of the opening in the pipeline
5 with a floating tubular member.

- 1 26. The system of claim 25, further comprising:
2 means for coupling the tubular member to the pipeline with a slip
3 joint.
- 1 27. The system of claim 25, wherein the means for covering at least a
2 portion of the opening in the pipeline with a floating tubular member
3 comprises:
4 means for radially expanding at least a portion of the tubular
5 member into contact with the pipeline.
- 1 28. The system of claim 27, wherein the means for radially expanded
2 tubular member comprises:
3 means for radially expanding the tubular member into contact with
4 the pipeline above and below the opening.
- 1 29. The system of claim 27, wherein the radially expanded tubular
2 member only contacts the pipeline above the opening.
- 1 30. The system of claim 27, wherein the radially expanded tubular
2 member only contacts the pipeline below the opening.
- 1 31. A method of repairing a damaged section of a structural support,
2 comprising:
3 removing at least a portion of the damaged section of the structural
4 support to create an opening in the structural support; and
5 covering at least a portion of the opening in the structural support
6 with a floating tubular member.
- 1 32. The method of claim 31, further comprising:
2 coupling the tubular member to the structural support with a slip
3 joint.

1 33. The method of claim 31, wherein covering at least a portion of the
2 opening in the structural support with a floating tubular member comprises:
3 radially expanding at least a portion of the tubular member into
4 contact with the structural support.

1 34. The method of claim 33, wherein the radially expanded tubular
2 member contacts the structural support above and below the opening.

1 35. The method of claim 33, wherein the radially expanded tubular
2 member only contacts the structural support above the opening.

1 36. The method of claim 33, wherein the radially expanded tubular
2 member only contacts the structural support below the opening.

1 37. A radially expandable tubular member for repairing an opening in a
2 structural support, comprising:
3 a tubular member; and
4 a slip joint coupled to the exterior surface of the tubular member.

1 38. An apparatus for repairing an opening in a structural support,
2 comprising:
3 a tubular support member comprising a first passage;
4 an expansion cone coupled to the tubular support member
5 comprising a second passage fluidically coupled to the first
6 passage;
7 an expansion cone launcher coupled to the expansion cone
8 comprising a shoe having an exhaust passage; and
9 an expandable tubular member coupled to the expansion cone
10 launcher comprising one or more sealing members having slip
11 joints.

1 39. An apparatus, comprising:
2 a structural support comprising an opening; and

3 a floating tubular member coupled to the structural support in
4 opposing relation to the opening.

1 40. A system for repairing a damaged section of a structural support,
2 comprising:

3 means for removing at least a portion of the damaged section of the
4 structural support to create an opening in the structural
5 support; and

6 means for covering at least a portion of the opening in the structural
7 support with a floating tubular member.

1 41. The system of claim 40, further comprising:
2 means for coupling the tubular member to the structural support
3 with a slip joint.

1 42. The system of claim 40, wherein the means for covering at least a
2 portion of the opening in the structural support with a floating tubular
3 member comprises:

4 means for radially expanding at least a portion of the tubular
5 member into contact with the structural support.

1 43. The system of claim 42, wherein the means for radially expanded
2 tubular member comprises:

3 means for radially expanding the tubular member into contact with
4 the structural support above and below the opening.

1 44. The system of claim 42, wherein the radially expanded tubular
2 member only contacts the structural support above the opening.

1 45. The system of claim 42, wherein the radially expanded tubular
2 member only contacts the structural support below the opening.

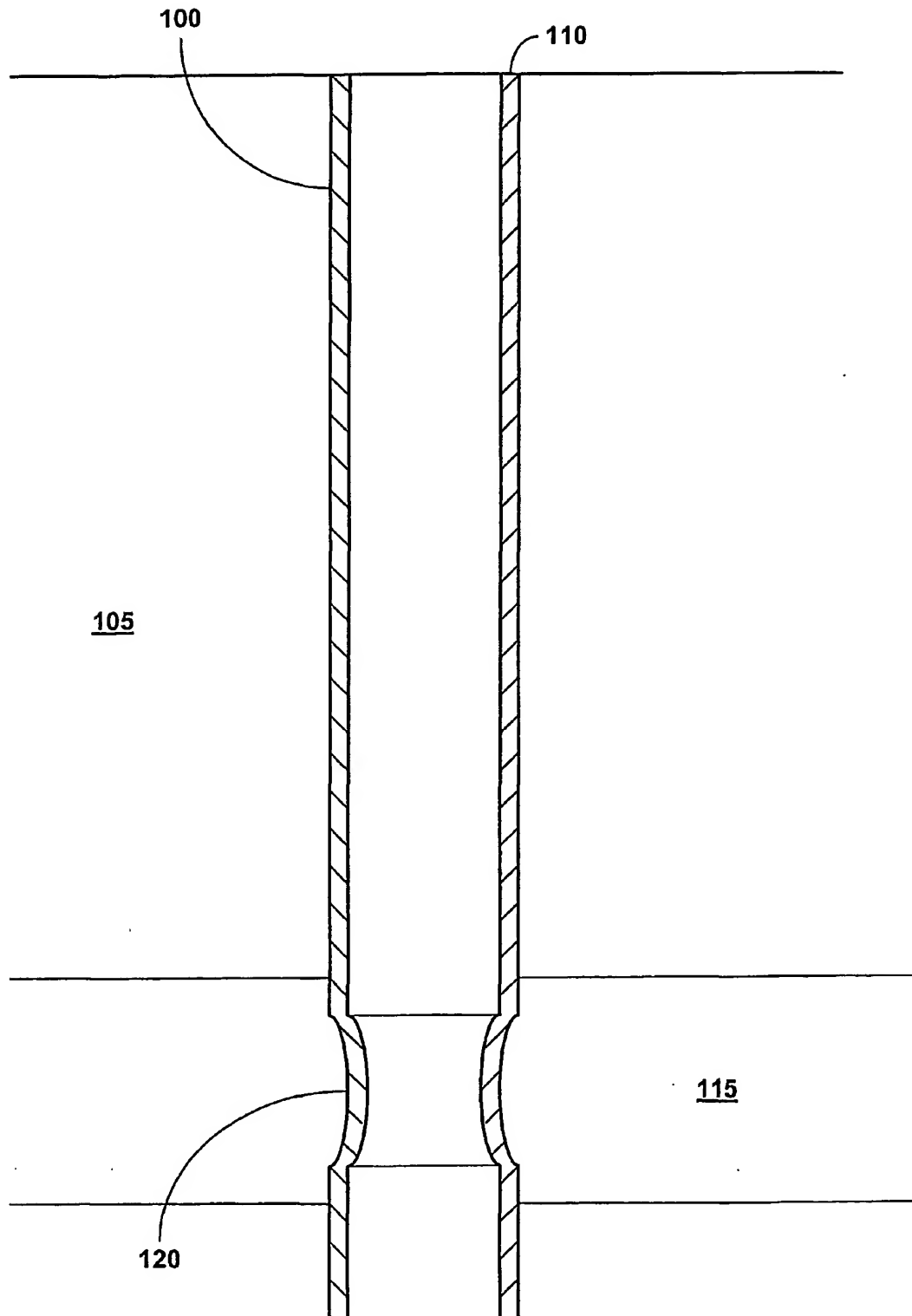


FIGURE 1

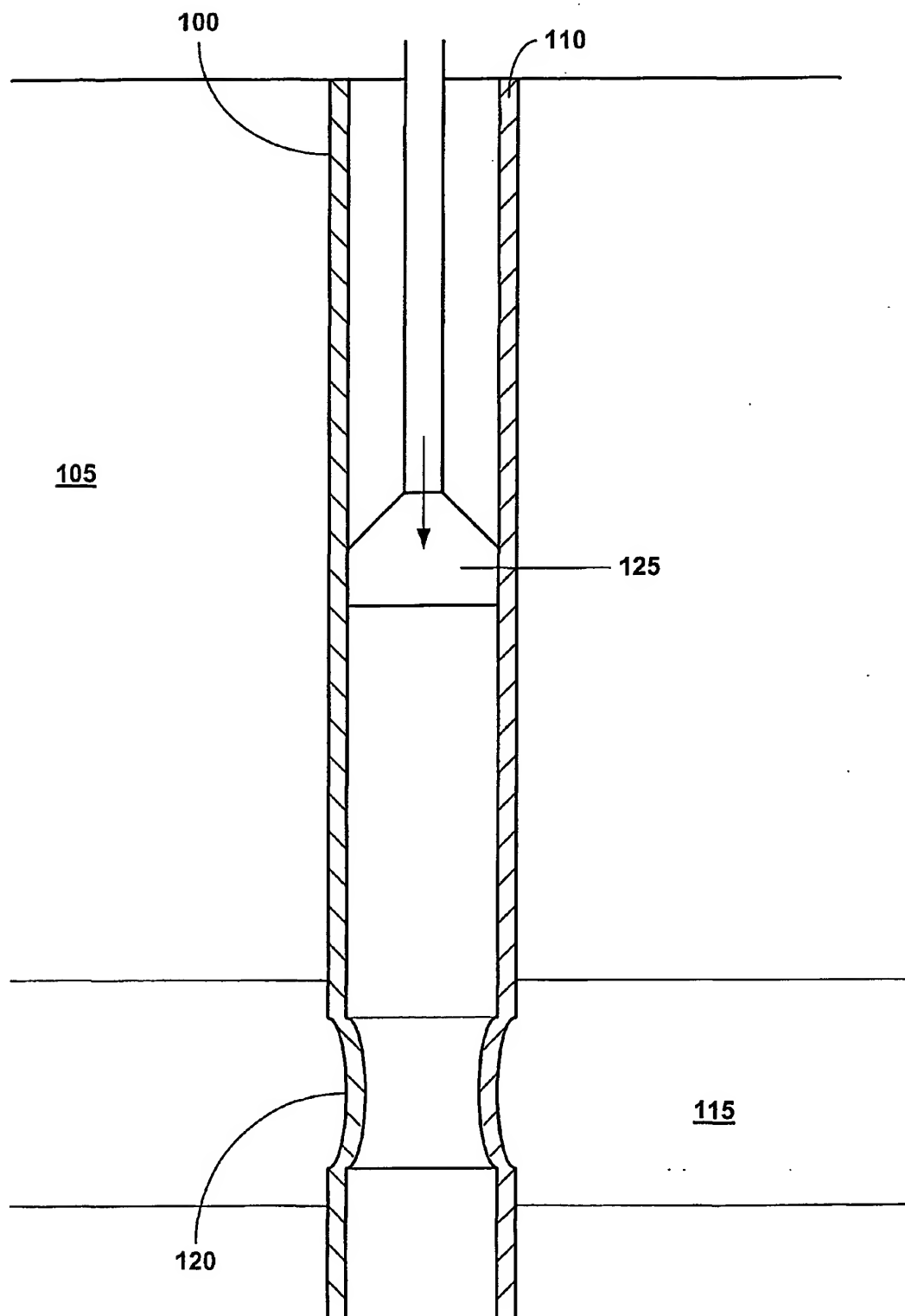


FIGURE 2

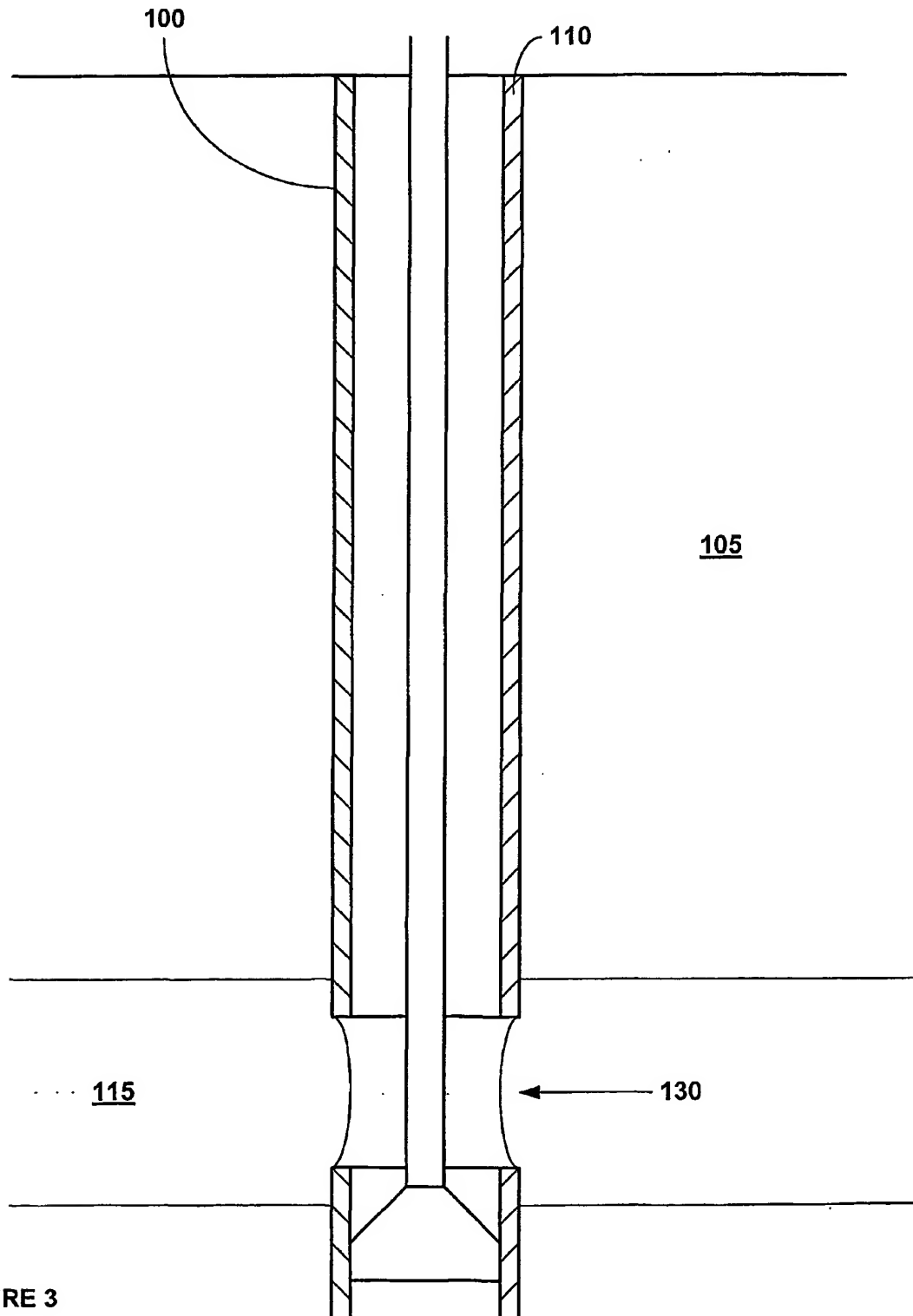


FIGURE 3

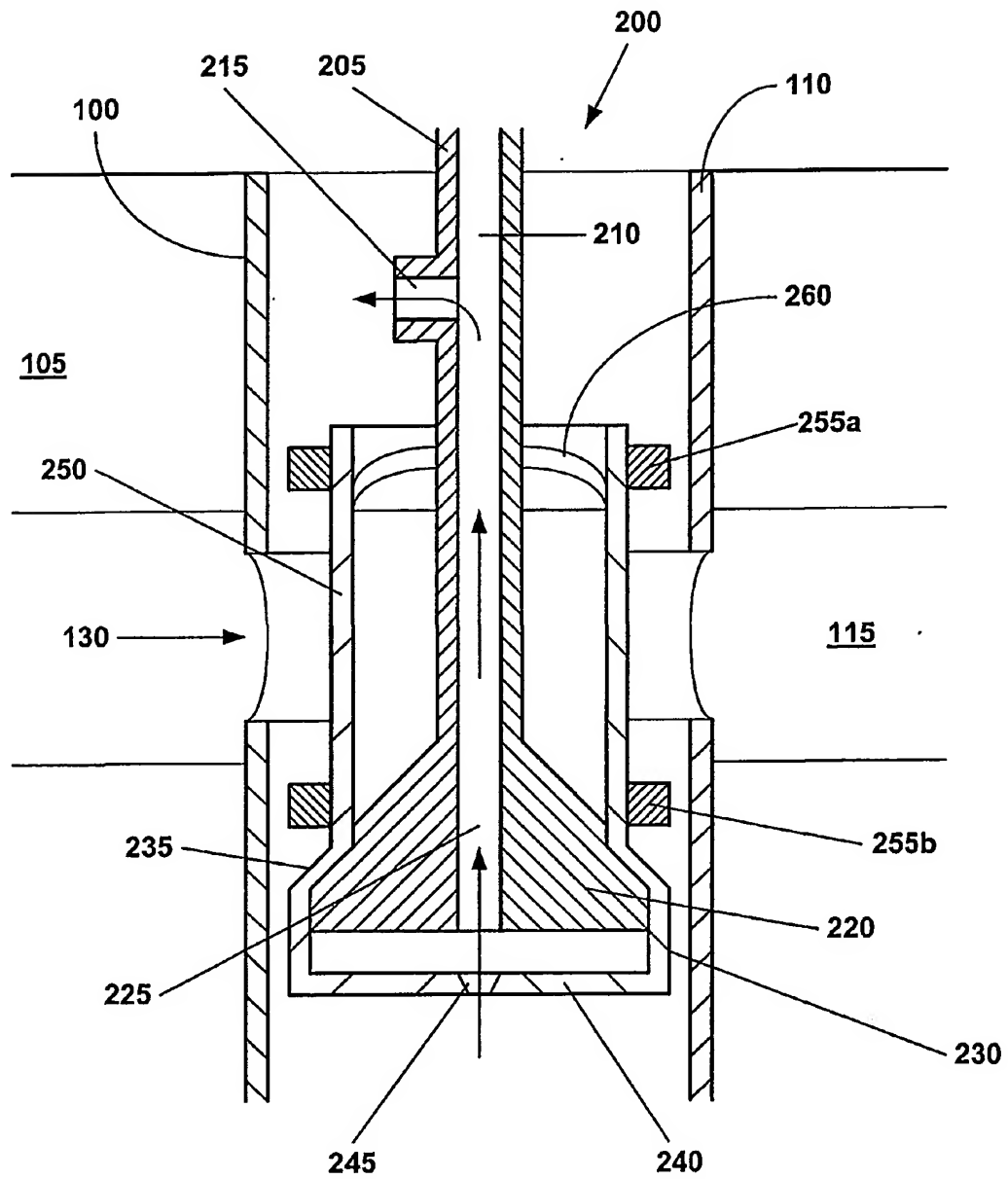


FIGURE 4

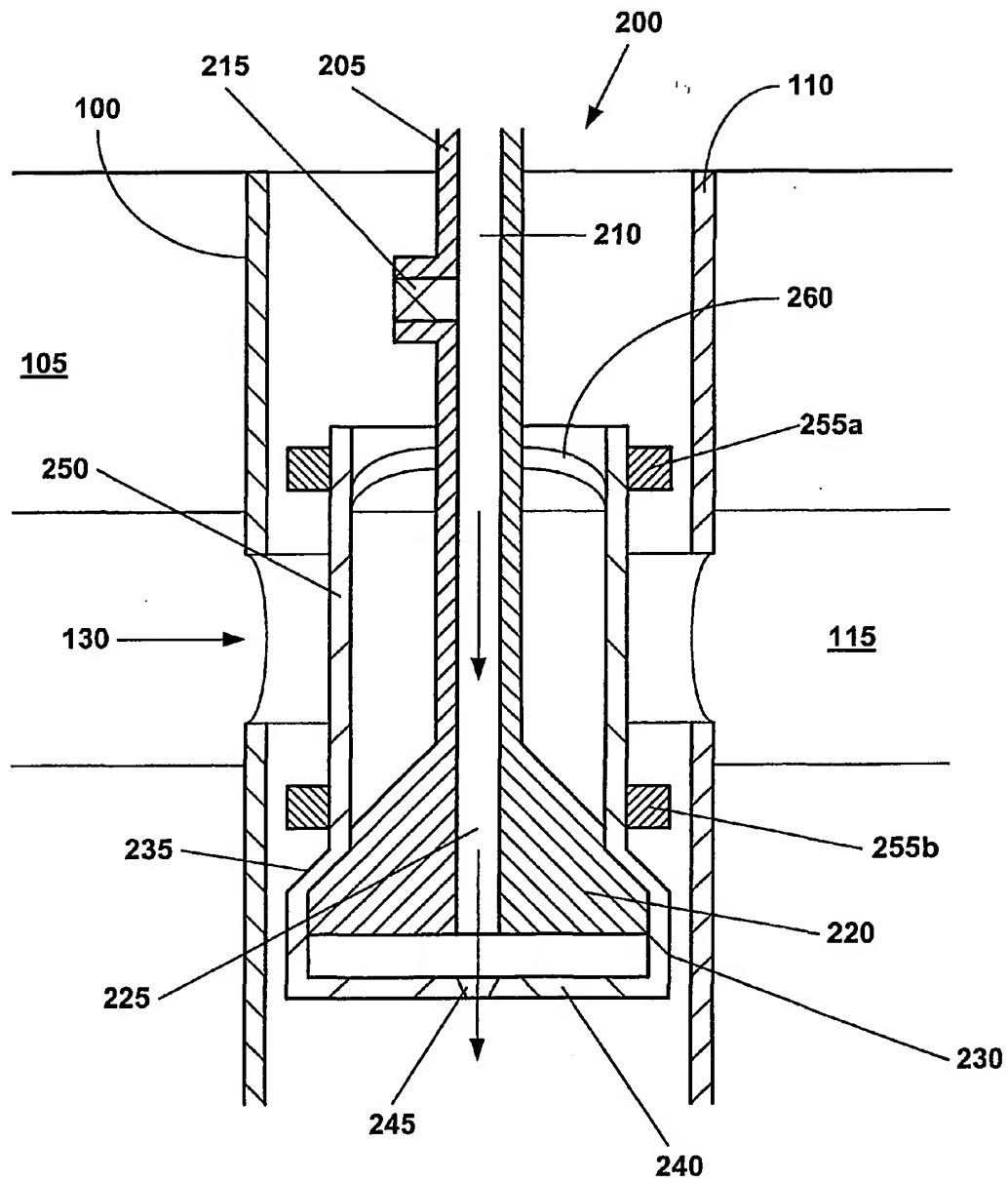


FIGURE 5

FIGURE 6

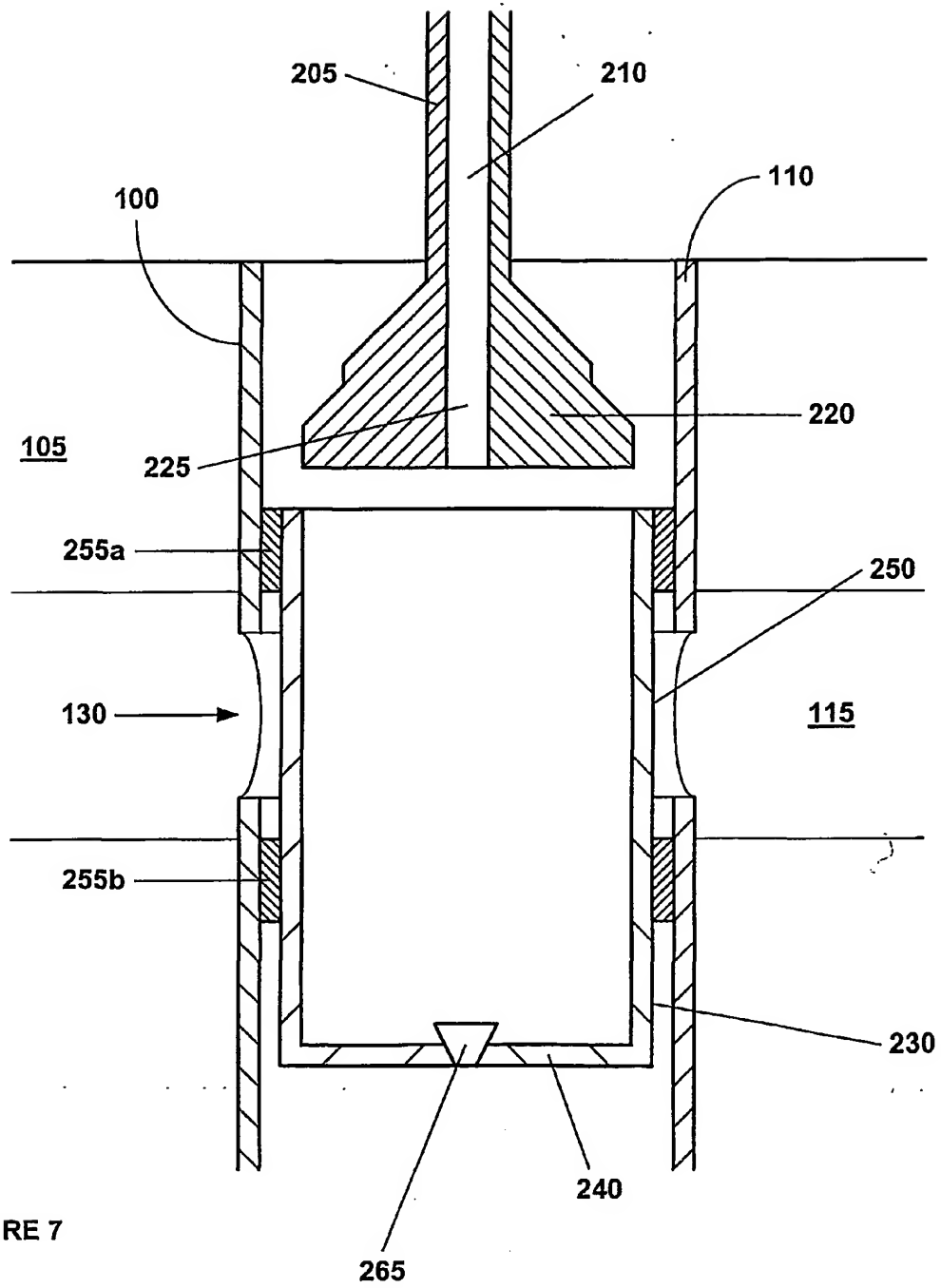


FIGURE 7

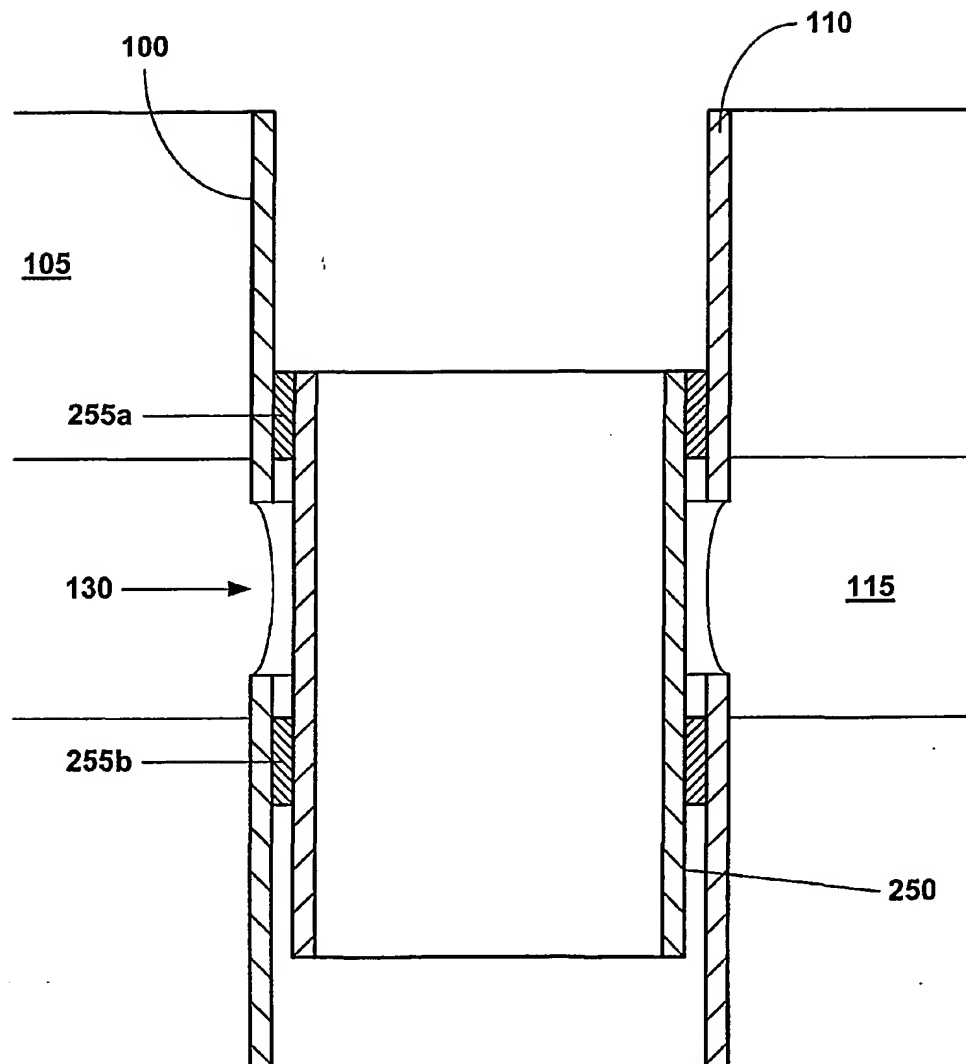


FIGURE 8

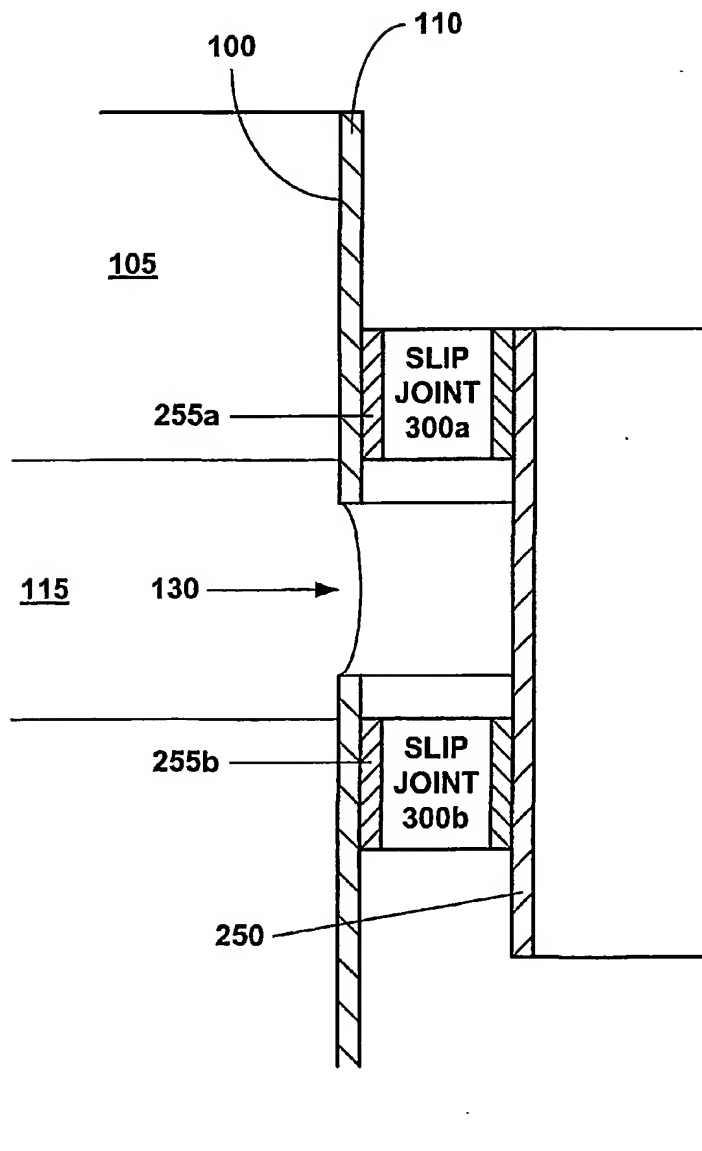


FIGURE 9